A Strategy of Cost Control for Mariner Venus/Mercury '73

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The spacecraft NASA launched on November 3, 1973 to explore Venus and Mercury proved a notable success both in space and on the ground, as a development project. This article on the development points out management approaches and techniques that kept schedules and controlled costs, the intent being to stimulate thought about how to do the same with future spacecraft and payloads.

The Mariner Venus/Mercury '73 (MVM '73) project kept within its originally established goals for schedule, performance, and cost. Underlying this development success was the availability of the Mariner technology. But meeting the goals demanded management determination, planning, and discipline to make optimum use of state-of-the-art technology—on the part of people at NASA, JPL, and The Boeing Co. (the main contractor).

Pre-project Highlights

The earliest studies of the concept and scientific potential of a Venus/Mercury swing-by mission drew many to observe it could be the unique mission of the decade. It was the first to use a gravity-assist technique—taking advantage of an unusual planetary configuration existing in 1973. Using the gravitational field of Venus, it was possible to swing an Atlas-Centaur-launched spacecraft onto a flight path to Mercury. Exploration of Mercury otherwise would not have been possible without employing a much larger launch vehicle.

The 1968 Planetary Exploration Summer Study conducted by the National Academy of Sciences (NAS) Space Science Board (SSB) endorsed this mission. The SSB suggested that the mission be planned around a single launch to make best use of the science funds available to NASA.

Mission Objectives

The following mission objective, established by NASA following the Summer Study in 1968, did not change during the program's several years of design and development:

> *Primary.* During the 1973 opportunity, to conduct exploratory investigations of the planet Mercury's environment, atmosphere, surface, and body characteristics and to obtain environmental and atmospheric data from Venus during the flyby. First priority goes to Mercury investigations.
>
> *Secondary.* To perform interplanetary experiments while the spacecraft flies from Earth to Mercury, and to obtain experience with a gravity-assist mission.

JPL had long experience with planetary programs, but the opportunity for other Centers to participate in the program was not foreclosed. NASA's Goddard Space Flight Center (GSFC) had plans for a Planetary Explorer spacecraft potentially able to do the mission and its approach was sufficiently attractive to invite further study. During the remainder of 1968 and 1969, both GSFC and JPL studied their respective concepts; this early competition contributed to thoroughness of the early planning effort.

The Scientists

An innovative technique was used on MVM '73 to assure early involvement of the scientific community with mission definition and preliminary design. In past missions, no effective mechanism for the early detailed planning involvement of outside scientists had evolved, and selection of principal investigators had been withheld until the completion of mission-profile studies and early system determinations. By the time the investigators were selected in those programs, many design features had already been established.

For MVM '73, selected scientists were invited to participate in the early mission planning. A group of scientists representing the several disciplines to be involved in the science payload was selected and formed into a Science Steering Group (SSG) in September 1969. The scientists influenced the early mission and spacecraft design, holding to a minimum conflict between mission constraints and science needs.

Based on the positive results from these planning efforts, MVM '73 was presented in the FY70 NASA budget as an Office of Space Science and Applications (OSSA) "new start" at a funding level of $3 million. An Authorization Conference Committee approved the project for inclusion in the FY70 authorization action, and funds were appropriated as requested. The scientific principal investigators were then selected in a normal fashion after project authorization.

Robert S. Kraemer, then head of planetary planning at NASA, pressed innovation in the early planning of MVM '73. Kraemer later moved to the post of planetary program director, with responsibility for implementing the project.

The "Low-cost" Attitude

The "low-cost" attitude, so evident in the management of MVM '73, developed early. The study teams were instructed to consider maximum use of established designs, residual hardware, and existing capabilities. Very strict financial constraints were factored into payload planning. The SSG was requested to consider minimum-cost experiments that would yield acceptable scientific data. The potential experiment proposers were advised to use existing designs for science instruments, to use flight-tested experiments wherever possible, and to consider modifications only for high-payoff options. They were also to limit quality assurance, reliability, and documentation requirements to that previously applied to prior successful similar instruments.

GSFC and JPL established the mission and spacecraft baseline, developed preliminary implementation plans incorporating the experiment approach being followed by the SSG, and made early cost estimates. JPL called on its extensive experience with Mariner spacecraft. Goddard proposed a spin-stabilized spacecraft of the Explorer class.

JPL proposed to commit to a fixed cost to do the MVM '73 mission in the system-contract mode. W.H. Pickering, JPL director, advised OSSA in December 1969 that JPL could and would undertake the project for a cost not to exceed $98 million.

The JPL Goal

After a full briefing on the approaches by GSFC and JPL (proposed science return, spacecraft configurations, management modes, manpower and cost projections), OSSA chose JPL. In a letter to Dr. Pickering, assigning project management to JPL, John E. Naugle, Associate Administrator for Space Science, made this comment regarding mission cost: "A major concern has been and remains to be the total runout cost of the project. I am sure you are aware of the cost history for which estimates have ranged from approximately $70 million to well over $100 million. It is mandatory that the project be accomplished for a total cost not exceeding the $98 million quoted in your letter and strong efforts should be taken to reduce this figure." This letter set the fundamental cost understanding between OSSA and JPL.

The "Work Package" Concept

JPL expertise in conducting flight projects predominantly involved obtaining spacecraft subsystems from industry thorough the JPL technical divisions with JPL accomplishing the spacecraft systems functions. The major challenge faced by JPL in the MVM '73 project was to utilize and adapt the fundamental JPL strengths to a system-contracting mode.

A JPL team suggested a "work package" concept as the best means to transition from the use of subsystem contractors to a systems contractor.

Appropriate elements of the JPL matrix organization prepared the work packages.

The Project Office exercised system technical direction, but the detailed definition, monitoring, and control of individual work units was performed by the appropriate JPL organizational element under the overall coordination of the JPL Project Office.

JPL also determined other factors important to implementing the project. It selected a cost contract with award fee. A specific JPL procurement group co-located with the Project Office would administer the system contract and other MVM '73-related ones. It was decided that the JPL in-house tasks should be given as much visibility and control as those of the system contractor. The constraint on resources dictated that all elements of the project, regardless of the performing organization, be monitored in the same detail, and the risks balanced across all portions of the project's activities.

PAD, Procedures and Payoff

The NASA project-approval process entails a basic contract or understanding between the Administrator and the responsible Program Associate Administrator: the Program Authorization Document (PAD). The initial PAD for the MVM '73 project was signed on February 27, 1970. The objectives, technical plan, major support interfaces, and procurement approach discussed in that PAD remained unchanged throughout the development.

The JPL approach strongly exercised the Mariner heritage. MVM '73 benefited not only from Mariner design derivation but also from residual hardware from past programs. The plan emphasized maximum use of existing designs, hardware and software. This approach saved perhaps 50 percent of design and development costs and perhaps 15 percent in hardware costs—a big payoff.

The Cutting Edge

The project team had lengthy discussions with JPL implementing organizations to identify the optimum way to meet cost constraints. Control of cost-at-completion became a basic concept stressed by both the JPL and Headquarters offices in an attempt to avoid the less-efficient, year-by-year funding controls often followed in projects. The MVM '73 project made it clear that each assigned work unit was the total responsibility of the cognizant division and that responsibility for determining the least costly way to do the work rested squarely with the division. For each potential increase in cost, something had to be cut back. The JPL divisions almost invariably proposed specific cuts concurrent with notification to the project office of potential cost increases.

Schedule Strategy

The schedule adopted for MVM '73 provided an unusually long period for advanced planning and deferred this start of major contracts. This approach, unprecedented in launch-critical planetary programs, may have been the single most important factor in meeting cost goals.

The added risk to the mission was offset by the increase in design time and better planning of the fabrication effort. The effect was to establish a "most cost-effective" approach. The greatest number of people worked on the project for the shortest period of time. (Axiom: the shorter the schedule, the less the cost.)

Once adopted as a project philosophy, delay in implementation was applied to all aspects of the project. The systems contract was delayed three months beyond the schedule considered minimal by many. Other subcontract work was released on a schedule that limited the work time to a prudent minimum. A "single thread" approach was followed in the spacecraft design where options were studied, one was adopted, and the work started without carrying parallel efforts. Mission operations work was held off beyond the schedule previously considered to be optimum. Flight operations crew training was held off as long as possible. And it worked! There were no major schedule slippages, no seriously late deliveries of equipment, and no extraordinary work-arounds.

"Do Only the Essential"

"Do Only the Essential" became a discipline among project participants. To challenge the need for each operation, each added procedure, each piece of special equipment, and each separate design, redundant feature or test became routine. If a function, part, or operation was determined to be needed, then the search went on to see if hardware was available from other projects, or if the process had been developed by someone else. If the part or process was not available, then there was an attempt to use available designs.

This discipline was not only applied by the JPL managers but by Boeing as well. The Boeing spacecraft program manager proved extremely resourceful in identifying short-cuts, reductions in paperwork, and unnecessary redundancy—the cost-type contract not withstanding. The list of hardware and effort saved through this effort is too lengthy to discuss here, but the savings extended to every area of the project effort.

One unusual saving is notable. The project team encouraged a local college, assisted by several other colleges and high schools, to produce the spacecraft models, which often cost more than $100,000. The project gained all the models required, the students and schools gained good experience from their work on an interesting task, and NASA saved dollars and encouraged local community interest and support.

Project Team

The most important ingredients to project success were the attitudes and skills of the people assigned to manage it. JPL's experience in dealing with a system contractor was limited to Surveyor, and by 1970 relatively few JPL people had been involved in the early stages of that project. The person most familiar with its operations was Walker E. "Gene" Giberson, who had been Surveyor's project manager. He was appointed MVM '73 project manager in January 1970.

Giberson assembled a small team of individuals, each selected on the basis of his past project experience and his willingness to work within firm budget allocations. The key members of this team included V.C. Clarke, Jr., mission analysis and engineering manager; J.A. Dunne, project scientist; J.R. Casani, spacecraft system manager; J.N. Wilson, assistant spacecraft system manager and N. Sirri, mission operation system manager, This team, trim in size yet representing broad experience, represented the core of MVM '73 project management.

The Guidelines

At first, the team spent considerable time developing the project's operating concepts and indoctrinating everyone involved with the organizational and project philosophy. They set and held to the following guidelines throughout the project:

- Establish early project guidelines, objectives and constraints
- Use a small staff for planning
- Prepare detailed plans and tasks before initiating a contract:
  - Specific and detailed RFPs
  - A careful tradeoff assessment between JPL and contractor furnished equipment
  - Use of existing documents, reports, and systems
  - Careful selection of fee approach
- Establish cost-at-completion planning, budgeting and emphasis
- Secure all contracts before starting work
- Keep work and budget plans up-to-date
- Exercise organizational impedance matching and communications
- Maximize technical interaction
- Use the concept of cognizant work unit engineer
- Hold frequent face-to-face meetings of operating managers
- Identify and resolve problems promptly
- Make periodic status and performance reviews
- Indoctrinate all involved with cost goals
  - Instill cost consciousness
  - Make cost goals believable
  - Develop a clear understanding of the cost-control system

- Bring manpower onto the project and move it off in a timely manner

The Hot Seat

The Headquarters Program Office/Center Project Office interface can be extremely critical to the success of a project. If the program manager and project manager have differing ambitions and objectives or, as occurred in some instances, an adversarial relationship, the project can suffer. N. William Cunningham, the Headquarters program manager, and Gene Giberson, the JPL project manager, enjoyed an open and forthright relationship, a cornerstone of a sound management structure.

The person on the "hot seat" for cost management is, however, the project manager. The project manager is the one most responsible for establishing the attitude and the framework for the daily tradeoffs of cost, performance, and schedule where it is most essential to maintain a proper perspective. Without his cost consciousness, his basic approach to costs, MVM '73 would not have enjoyed it obvious cost success. This cost attitude is the more unusual since NASA had previously stressed technical performance and schedule requirements over cost as a discipline.

The Science Steering Group selected in September 1969 held its final meeting in March 1970. In its report, the SSG recommended a minimum science payload composed of a plasma science experiment, a magnetometer, an infrared radiometer, an ultraviolet spectrometer, a television system, and an energetic particles experiment.

One of the tasks of SSG was to make a detailed cost estimate for each potential experiment—including design, development and fabrication costs of the hardware, cost of personnel support for launch and mission operations, and cost of data analysis and interpretation and publication of results. These cost estimates, plus a project estimate for integrating the instruments into the spacecraft, shaped the first science budget for the project at $13 million.

An Announcement of Flight Opportunity (AFO) issued in March 1970 invited proposals for experiments. It stressed the intent to select only proven flight-qualified instruments. The AFO also stressed the desire to minimize documentation and stated the intent of JPL to monitor development of the instruments only at the interface level.

Forty-six proposals were received and evaluated. After ranking them in terms of science excellence, technical and engineering requirements, cost and system integration, the program office recommended seven payloads to the OSSA Associate Administrator. The payload cost estimates went as follows (in millions of dollars):

Television	$6.226M
Radio science	0.500
Ultraviolet	0.575
Infrared	0.928
Magnetometer	0.688
Energetic particles	0.383
Plasma science	0.945
Total	$10.245
Instrument integration	2.355
Total	$12.600

To each of the principal investigators selected, Dr. Naugle addressed this comment: "I must emphasize, once again, that the total negotiated figure (dollar cost as selected) cannot be exceeded. Accordingly, I have instructed the JPL Project Office that in the event of an anticipated cost overrun, their alternatives will consist of helping you to reduce the scope of your experiment, or recommending its termination."

Science and Dollars

Whereas most past selections had been considered final at the time of announcement, the letter from Dr. Naugle clearly pointed out that the selection was to be considered tentative until the investigators and JPL completed negotiations. A process of fact-finding and negotiation between JPL and each of the scientific investigators followed, which resulted in well-defined relationships before the major development effort commenced.

It was made clear in the selection and negotiation process that the principal investigator was responsible for the implementation and development of the investigation, including the instrument. The project office followed through on the intent to control principally at the instrument/spacecraft interface level. The systems contractor was responsible for integration of the instruments into the spacecraft.

One innovative technique required the systems contractor to "sign off" on changes to experiment interface drawings, although the contracts for the experiments were between JPL and the investigator. This technique provided greater assurance that the systems contractor was aware of the latest configuration of the experiment hardware, and helped avoid surprises at the time of integration.

Dr. Naugle views MVM '73 as the most successful development of scientific instruments within tight cost constraints. The addition of the experiment integration costs to delivered cost brings the total for science very close to but within the original budget of $13 million.

Meeting payload cost goals begs the question whether controls compromised the science investigations. A detailed review of the development history of each instrument clearly demonstrated that not only was there no compromise of the investigations during development, but that significant capability was added to several investigations. Any science compromise on MVM '73 reflects directly the original constraints established before experiments were selected. The decisions to tightly constrain payload costs, to fly only proven instruments, and to apply go/no-go cost restrictions on instrument development are serious policy decisions to be carefully weighed and considered. They cannot be applied to every payload but they paid off in MVM '73.

NASA and JPL held an industry briefing in February 1970 to apprise companies of the goals and constraints of the MVM '73, to provide detailed technical and program information for early planning, to encourage competition, and to enlist industry's help in determining an optimum role for a system contractor. Forty-one firms attended the briefing.

JPL asked the companies for suggestions regarding implementation of the systems contract approach; separate day-long meetings were held with the most interested competitors to discuss their suggestions. During these meetings, the companies made recommendations on contract scope, roles and relationships, Mariner technology transfer, contract type, GFP handling and other areas they believed were important to the success of the effort.

A procurement plan evolved in which the systems contractor would have the major role (1) to design, fabricate, assemble, and test one flight spacecraft, one test spacecraft, associated test models, test and support equipment and appropriate spares; and (2) to provide level-of-effort support to JPL in mission analysis and engineering, JPL subsystems activities, and mission operations.

RFP Features

The JPL project definition effort had been proceeding for a year at the time the Request for Proposals (RFP) was issued. The result of that effort was a very detailed, explicit RFP. It was an extensive compendium explaining project objectives, project organization and implementation, schedule, project control dates and documents, work breakdown structure, spacecraft design summary, scope of contract, general description of work, JPL/contractor relationships, and mission operations. Its most unusual features included these:

- A spacecraft systems specification which attempted to state only minimum requirements.
- The predetermined intent to divide all work into discreet work units (which allowed separation of responsibilities and facilitated work description, understanding, negotiation, and JPL monitoring). The definition of each work unit was written in a standard format.
- The request for firms to propose overhead cost ceilings.
- The request for baseline and alternate cost proposals to get the best cost mix between JPL and contractor-furnished equipment.

- A call for incentive proposals which gave heavy emphasis to cost, but also statedstrong preference to award fee.
- Emphasis on minimum documentation and maximum use of procedures, forms, techniques, etc., that the contractor currently used.
- Detailed documentation covering Mariner '69 hardware, Mariner '71 hardware, and other JPL-furnished equipment, along with drawings, schematics, processes and procedures to assure full use of the Mariner heritage and facilitate cost estimates.

Four proposals were received. The Source Evaluation Board presentation was made to the NASA Administrator on April 28, 1971, and The Boeing Co. was selected as the systems contractor.

Holding Out for a Firm Negotiated Contract

The pressure to award the contract and commence work was very strong following the April selection, but the project manager and contract manager held out for a firm negotiated contract before allowing work to be started. Within six-and-one-half weeks after selection, the negotiations were completed and a definitive contract was awarded. Work started on June 17, 1971.

The contract, a cost-plus-award-fee type, emphasized the contractor's complete responsibility to meet the spacecraft system performance requirements. The contract effort was divided into work units, each assigned to a manager within The Boeing Co. The work units included in the contract were compatible with both JPL's technical division organization and Boeing's project structure.

Controlling Overhead

A serious concern in systems contracting had been the inability to predict overhead costs. The parties agreed that a ceiling on overhead costs would be negotiated into the contract. Such ceilings on overhead are unusual in normal circumstances, and all the more so in this case, considering the depressed economic situation The Boeing Co. faced in the spring of 1971. The ceiling on overhead never was invoked because Boeing actually underran the negotiated overhead cost.

There were strong cost incentives negotiated into the contract and a process for evaluation and award was developed with emphasis on performance and cost control. The award fee provisions and the system employed to carry them out appear to have been effective in contributing to the contractor's performance. Benefits included these:

- Boeing's spacecraft program manager had the opportunity to increase the fee significantly. The award fee structure allowed broad latitude in the approach to cost and performance tradeoffs.
- The process enforced periodic, results-oriented evaluations and communications at all levels. The process and the resultant dialogue tended to remove the obstacles that stand in the way of the natural motivation to do a good job. By clarifying goals, establishing emphasis, eliminating misunderstandings, and highlighting problem areas for mutual attention, obstacles were removed or reduced.
- Attention of the contractor's top management was obtained by the formal feedback process (briefings supported by letters).

Category of Indirect Expense	CY 1971 Negotiated Per Contract	CY 1971 Actual	CY1972 Negotiated Per Contract	CY1972 Actual
Engineering	$3.94	$3.74	$4.14	$3.88M
Manufacturing	4.99	5.08	5.24	4.97
Productive Material	10.5%	7.9%	10.5%	6.7%
Subcontract Material	6.1%	5.5%	6.1%	3.6%
Area Administration	15.1%	14.35%	15.1%	11.9%
Group Administration (remote)	9.6%	9.75%	9.6%	7.8%

- The discipline of the award fee evaluation process improved JPL's internal communications at all levels, including top management on the award fee review board.

Tight Control

JPL has a reputation in the industry for aggressive contract management, often expressed as complaints of "too tight control" by subcontractors. But the JPL system proves effective in assuring performance.

In MVM '73, change orders were kept to a minimum throughout the contract and were negotiated into the contract promptly after issuance. Project office personnel monitored Boeing's work very closely. The work unit breakdown made it possible for cognizant JPL engineers to thoroughly understand the job, follow its progress in detail, and identify potential problems early.

Early identification of problems coupled with open, candid discussions among The Boeing Co. and JPL managers were basic contributors to the success of the project. D.T. Gant, contracts manager, L.V. Burden, financial manager, and L.M. Bates, cost analyst, who were collocated in the project office, effectively kept the project managers alert to unexpected deviations.

The NASA Management Audit Office, not noted for its approbative descriptions of NASA operations, gave this appraisal: "In our opinion, the JPL surveillance of the contract, its assignment of capable and motivated personnel to monitor the performance of MVM '73 on a full-time basis, and the apparent stringent cost controls implemented by The Boeing Co. before contract award, and retained throughout the program, contributed to Boeing's successful cost performance under MVM '73."

Good Communications

Stressed by the managers, good communications led to early anticipation and resolution of issues and the timely availability of data for decision making. Some of the techniques used to assure good communications included:

- A weekly "Agreement/Disagreement Log," maintained by work unit personnel and reviewed by the JPL spacecraft system manager and The Boeing Co. spacecraft program manager.
- Weekly face-to-face meetings between the systems contractor, systems manager and the systems contractor program manager.
- A weekly summary of agreements and formal tracking of action items.
- Daily meetings between The Boeing Co. test and operations representatives and the JPL resident staff during the system test period.
- Weekly "Problem TWX."
- Formal monthly progress reviews to give an overview and detailed status and plans with particular emphasis on problems.
- Easy access to The Boeing Co. and JPL top management (above the level of project personnel).
- Attendance at award fee briefings by Boeing's top management.
- An extensive and definitive award fee letter and briefing, held not later than 15 days after the end of each period.
- Rapid escalation of significant problems to the appropriate management level for resolution.

None of these actions should surprise good managers, but taken together, they may not be commonplace. These combined techniques greatly helped the MVM '73 project meet its goals.

Highlights of Contractor Performance

The Boeing Co. faced an uncertain general business position at the time the MVM '73 project contract was issued. Major reductions had been made in Boeing's commercial airplane operations, and significant reductions in employment had been made at Boeing Aerospace Co.

Despite the drastic reduction in backlog and direct workload, Boeing was able to reduce overhead costs and even underrun the overhead projections on the MVM '73. The aerospace industry and its government customers are conditioned to the increase of overhead runs when the direct base decreases. This "fact" is considered by many to be axiomatic and inviolate—overhead costs regarded as "fixed" or unalterable and necessary to support the base for doing business. The example of Boeing's experience in 1970 and 1971 could be a good case study in ways to reduce overhead expense as the direct base decreases.

E. Czarnechi served as The Beoing Co. MVM spacecraft program manager from the early proposal phases in 1970 through early 1973. H. Kennett served as deputy program manager and succeeded Czarnechi. Their participation contributed immensely to the success of MVM '73. They have reviewed their experience, and underscored these management concepts and techniques employed on MVM '73:

- Spacecraft requirements must be defined clearly and early.
- Match people (skills) to work unit tasks.
- Use the "cognizant work unit engineer" concept
- Select the baseline configuration early.
- Implement a system of program reviews and reporting with joint chairmanship by contractor and customer.
- Define and assess technical performance, schedule, and cost risks, and develop work around plans.
- Educate key personnel in the company's cost-accounting system so that when tradeoffs and decisions are to be made, all factors are properly considered and their true impact on cost understood.
- Shorten and improve communications through collocation and program organization
- Establish organizational relationships (e.g., JPL/Boeing) and communication channels early.
- Motivate people through performance assessment, promotion, compensation, and achievement awards.
- Emphasize cost trades during design phase.
- Ensure that only essential work is accomplished.
- Use an objective performance measurement system.
- Rely on each cognizant work unit engineer for early identification, reporting and, when feasible, problem resolution.
- Use dedicated manufacturing and test facilities.
- On-load and off-load manpower in a timely fashion.
- Use recovery ("tiger") teams to work problems. Teams of specialists from outside the program can be assigned problems and provide instant expertise without a continued expense to the program.

A Postscript

The MVM '73 spacecraft (Mariner 10) was launched on November 3, 1973. A number of problems developed early in the flight, but none degraded the mission and none was the obvious result of actions taken to control cost. The spacecraft reached Venus on February 5, 1974, and returned a full set of scientific data, including more than 4,000 pictures. The gravitational attraction of Venus altered the spacecraft's flight path as planned, swinging it toward Mercury. The spacecraft passed within 500 miles of Mercury's surface on March 29, 1974, and returned the first close scientific observations and pictures of the planet.

The project is currently [1974] anticipating a modest underrun at completion. So MVM '73 more than met its original performance objectives and, in addition, served to work out management approaches and techniques to control costs.

Science Cost History

Experiment	Appointment Letter Cost/ OSE[1]	Original Negotiated Cost (March 30, 1971)	Estimated Cost-at-Completion $(October 31, 1973)	±Cost-at-Completion
Infrared Radiometer	$ 789,000/ 21,000	$ 759,000	$ 726,000	- $84,000
Plasma Science	945,000/ 75,000	1,020,000	1,020,000	0
Charged Particle Telescope	383,000/ 8,000	391,000	505,000	+ 114,000
Magnetic Field	685,000/ 25,000	710,000	671,000	- 39,000
Ultraviolet Spectrometer	575,000/ 24,000	575,000[2]	705,000	+ 106,000
Television Science	475,000/---	475,000	555,000	+ 80,000[3]
Radio Science and Celestial Mechanics	500,000/---	500,000	500,000	0
	4,505,000	4,430,000	4,682,000	+ 177,000
TV System	5,751,000	5,765,000	5,787,000	+ 36,000
TOTAL	$ 10,256,000	$ 10,195,000	$ 10,469,000	+$213,000

(1) OSE–Operational Support
(2) Did not Include Bench Checkout Equipment (BCE)
(3) Raw Mosiac Costs–Change In Scope